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WEATHER DYNAMICS
DIVISION MT. AUBURN RESEARCH ASSOCIATES, INC.
385 ELLIOT STREET
NEWTON, MASSACHUSETTS 02164
617-969-7150

7 February 1975

Mr. Vincent Moore
Saratoga Associates, Inc.
The Arcade
Saratoga Springs, New York 12866

Dear Mr. Moore:

As per our conversation yesterday I enclose a copy of our revised proposal for a Preliminary Wind Effects Study of the Park Plaza Project, Boston, Massachusetts. I suggest you discard the original proposal dated 23 December 1974 to avoid any misunderstandings. Today's revised proposal covers a study of present-day conditions at 14 locations near the project area, plus data for the same locations with a model of the maximum density development on the project site.

This will serve to indicate the maximum change in wind conditions which might be anticipated near the project site. If there is a need for alleviation techniques at final design stage it may be necessary to conduct further tests at a later time.

If you have any questions on the proposal please call me.

Sincerely yours,

T. I. McLaren
Manager

cc: Mr. Tony Blackett, BRA ✓

Enclosure

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DIVISION MT. AUBURN RESEARCH ASSOCIATES, INC.
385 ELLIOT STREET
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617-969-7150

Document No. 2/7/75 (McL)

Proposal for a

PRELIMINARY WIND EFFECTS STUDY OF THE PARK PLAZA PROJECT, BOSTON, MASSACHUSETTS

Submitted to

SARATOGA ASSOCIATES, INC.
The Arcade
Saratoga Springs, New York 12866

Revised

7 February 1975

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1. INTRODUCTION

This proposal is for a study of near ground wind effects due to the proposed Park Plaza development in downtown Boston. Concern is directed towards pedestrian level wind effects on the sidewalks adjacent to the project site, i.e. along Boylston, Arlington and Stuart Streets, and on the Boston Garden and Common.

It is proposed here to conduct a wind tunnel study of the project area, including the Common and Garden, to identify wind activity (frequency of occurrence of various wind speed ranges) for the present day site and for the maximum density development envisaged at this time. Since final design plans will result from a detailed analysis of many parameters in addition to the physical aspects of the project, it is felt that this approach will indicate the maximum impact of wind effects associated with the development, and will also provide a baseline reference of present day wind conditions in the area.

The predictions of on-site climatology will be based on the wind tunnel measurements and records of ten-year averages at Logan Airport which are expected to be representative of conditions incident on the site area. Moreover the comparison of wind tunnel data for a model of the present day site with the developed site will provide an internal consistency in the test data to alleviate any minor variations in wind conditions incident on the site with those occurring at the airport.

The wind tunnel model would include an area of the city within a radius of about one-half mile from the project site plus major topographical or architectural features of interest outside this range.

It is proposed to utilize the 1"=40' scale model of the site area which is presently located at BRA. The model would be extended at MARA to include any additional buildings in the area which are deemed relevant to the study.

Velocity measurements would be made in the wind tunnel at 14 locations around the model of the site area using a Disa hot film anemometer system. The measurements would be combined with occurrence frequency statistics for Logan Airport to provide data indicating the occurrence frequency of approximately head-high wind speeds in ranges 0-10, 10-20, 20-30, 30-40, and over 40 mph. This pedestrian-level wind data will be interpreted in the light of best available information on wind effects on human activities.

The Weather Dynamics Division of MARA has carried out a number of studies in recent years with direct relevance to the proposed study. These are discussed in Section 4, Qualifications of the Corporation. They include a number of studies to quantitatively and qualitatively describe air flow patterns over topographic features as well as around buildings and building complexes. A recent wind effects study by MARA on the proposed 60 State Street building at Government Center in Boston was included as part of the Environmental Impact Statement for that project. In this study locations with undesirable levels of wind

activity were identified and design modifications were subsequently tested and shown to be effective in reducing wind speeds to acceptable levels. The study proposed here would follow similar lines to those used in the initial 60 State Street study. If problem areas are identified, and still exist at final design stage, it is anticipated that alleviation techniques would be investigated in a subsequent phase of the study.

2. TEST FACILITIES

2.1 The MARA Wind Tunnel

The modeling test program will be carried out in the MARA low speed wind tunnel. The tunnel is 8'x 6' section x 32' long. It was built specifically to simulate the interaction of the natural winds with buildings and large scale topographic features. Free-stream air velocity in the tunnel is variable up to 10 feet/sec, providing a Reynolds number = 6×10^4 per foot. With typical model sizes on the order of a foot, tests are carried out well into the high Reynolds number range needed to provide valid simulation of air flow patterns. The atmospheric boundary layer profile is modeled via two parameters: (a) the mean boundary layer velocity profile is scaled using a series of grids at the entrance end of the tunnel; (b) the atmospheric turbulence structure is modeled using turbulence generators located upwind of the models in the wind tunnel.

2.2 Flow Visualization

Facilities at MARA include the unique application of a system employing neutrally buoyant, helium filled soap bubbles. This system allows the observation of flow patterns in regions of highly turbulent flow where conventional smoke visualization techniques would prove useless due to dilution of the smoke in the turbulent region. The

necessary photographic recording equipment and lighting is also available. Figure 1 illustrates the flow visualization system in operation.

2.3 Velocity and Pressure Measurements

Conventional flow velocity anemometers (DISA) and associated electronic control circuitry, pressure transducers, oscilloscopes and meters are available. These provide for the measurement of local flow parameters including the fluctuating components. Outputs provide detailed information on the air flow velocity distributions.

2.4 Plume Concentration Measurements

Studies of plume dispersal are made using a flame ionization detector to measure the concentration of a hydrocarbon tracer gas released with the model effluent in the MARA wind tunnel. A multiplexing Scanivalve allows one to conveniently monitor up to 48 test locations without adjustments inside the tunnel.

2.5 Model Shop Facilities

A large laboratory including a model shop which provides all the necessary facilities for production of scale models of structures and buildings for wind tunnel studies. Architectural and engineering modifications to design can be incorporated into the models with minimum inconvenience. Figure 2 shows a model of part of downtown Boston in the

FIGURE 1

The picture shows a rectangular block model (Height:Width ≈ 1) in the MARA wind tunnel. The air flow is from right to left and camera exposure time 0.5 secs. The white streaks show the paths of the helium filled soap bubbles which follow the air flow. Note how the air is deflected downward in front of the building from a point (in this case) about one-half the building height. It forms a standing vortex pattern in front of the building which is characterized by a relatively high speed circulating air flow.

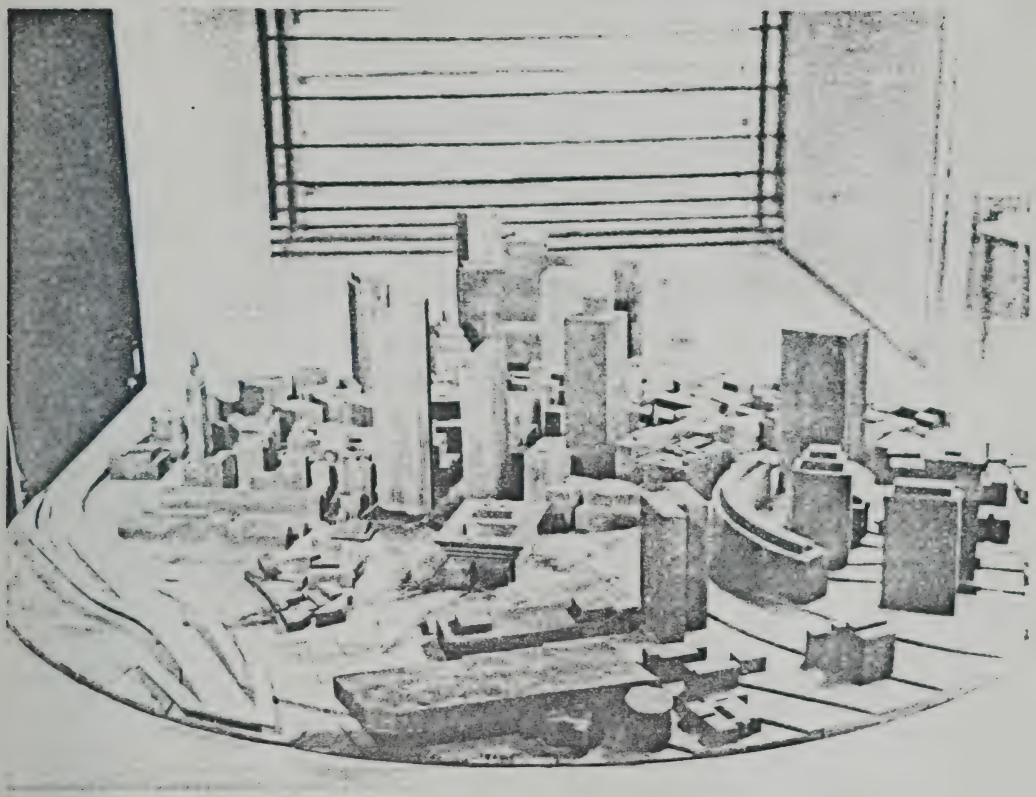

FIGURE 2

Part of a model of the Government Center, Boston, in the MARA wind tunnel.

MARA wind tunnel during testing on a high-rise building proposed for that area.

2.6 Computing Facilities

Computing requirements are usually met with an in-house Data General Disk System capable of solving problems in FORTRAN IV, BASIC, and ALGOL. In addition, a Wang 720 Programmable Calculator with output writer, is used to solve smaller problems and for automatic, on-line reduction of wind tunnel test data. For very large programs, time is purchased on conveniently located CDC 6600 systems.

3. STATEMENT OF PROPOSED WORK

Mt. Auburn Research Associates, Inc. offers to perform the following tasks:

1. Transport the 1"=40' model of the project area presently at BRA to the MARA laboratory and modify and extend it as necessary for use in the proposed wind tunnel study.

2. Conduct a wind tunnel test program to analyze pedestrian height wind speeds at approximately 14 locations of interest. Suggested locations are indicated on Fig. 3. These will be reviewed prior to testing by MARA and BRA personnel. Quantitative measurements of wind velocities would be made using conventional wind tunnel annemometry. Tests would be made for 16 incident wind directions, i.e., N, NNE, NE, ENE, etc.

3. Reduce the data from the wind tunnel tests. Occurrence frequencies of incident wind conditions will be based on National Climatic Center records for Logan Airport. Data will be presented to show the occurrence frequency of pedestrian height winds at the respective locations in velocity ranges: 0-10, 10-20, 20-30, 30-40, and $\geq$ 40 mph.

4. Discuss the implications of data generated under item 3.

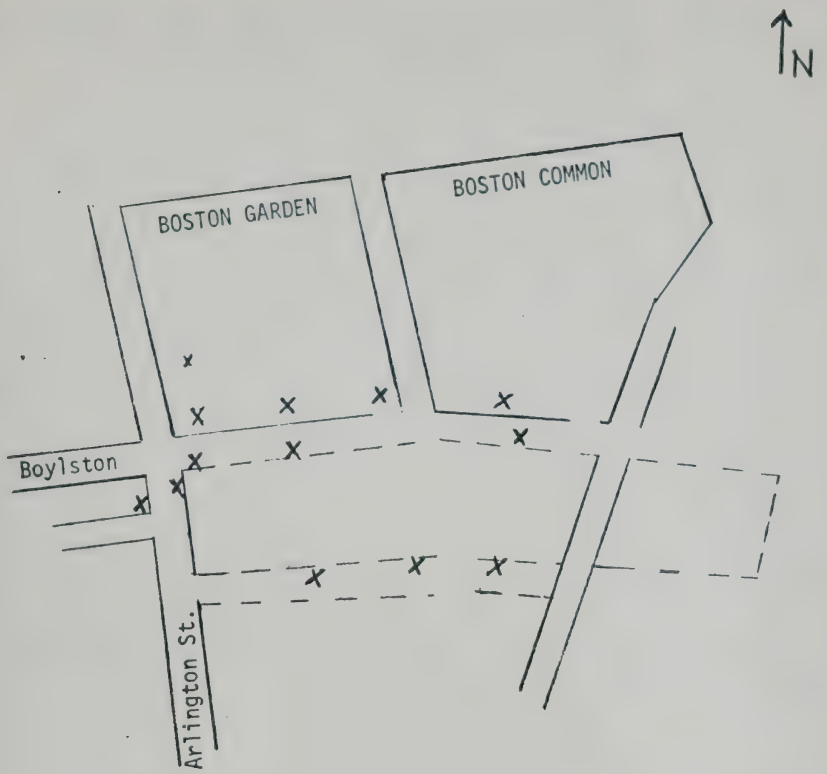

FIGURE 3. Schematic, not to scale, illustrating 13 locations for proposed test data. A 14th location will be specified by BRA personnel prior to testing.

x indicates suggested location for pedestrian-height wind measurements.

5. Present a final report on completion of the study. This will include all relevant data from the study and a presentation of climatological data for the site area. Twenty copies of the report will be provided.

4. QUALIFICATIONS OF THE CORPORATION

4.1 The Corporation

Mt. Auburn Research Associates, Inc. was established in 1962. It performs theoretical and experimental work in basic and applied physics related to the atmosphere, ionosphere, and exosphere. The Weather Dynamics Division was formed in 1970 to investigate problems resulting from the interaction of natural winds with obstacles such as buildings or low level topography.

Technical staff of Mt. Auburn has training and experience in several different areas of applied science. Areas of interest to the proposed study include:

Fluid mechanics of the atmosphere and ocean

Vortices shed from buildings and aeroplanes

Air pollution dispersal patterns

Applied mathematics, especially computer techniques and numerical analysis

Hydrodynamics, turbulence and shock wave propagation

Mt. Auburn Research Associates, Inc. has performed theoretical and experimental work for a number of government and other organizations. These are listed in Attachment A.

4.2 Relevant Experience

The Weather Dynamics Division at MARA has carried out a number of comprehensive studies on wind flow behavior related to topography and buildings. A list of recent or current work is included in Appendix B. Wind effects studies have dealt primarily with three aspects. These are: (1) problems involving pedestrian level winds near buildings including an assessment of the discomfort or danger to pedestrians in these areas; (2) an evaluation of wind pressure loading on the building surfaces; and (3) the dispersal patterns of fumes or effluents, including the cases where the dispersal is influenced by the presence of the buildings or topography. Alleviation techniques have been studied for cases involving both present-day problems and potential problems anticipated with new projects.

A recent study* on the proposed 60 State Street building at Government Center, Boston, provided information on pedestrian level wind activity in the area adjacent to the tower buildings. Locations subject to unpleasant or dangerous wind speeds were identified and wind activity levels were quantitatively assessed. Alleviation techniques were suggested and tested for some of the problem areas. Comparative data was included for some present day locations in the area which are recognized as being undesirably windy. The study proposed here for the Park Plaza development would follow similar lines to those used in the 60 State Street study.

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* Reference 6, Appendix B.

An earlier study of a two-square mile campus site at Buffalo/ Amherst, New York, involved a detailed investigation of air flow patterns throughout the campus area. Of particular interest were the effects induced by the various buildings on the pedestrian height wind speeds. These included problems created at "air-rights" configurations, on exposed plaza areas, and at entrances to underpasses (tunnels) and doorways. Dispersal patterns for noxious fumes from science buildings on campus were examined qualitatively and quantitatively using a photometric technique.

4.3 Personnel

The personnel of MARA Weather Dynamics Division have a wide range of relevant experience in fluid mechanics, meteorology experimental research, and state-of-the-art computing techniques. Full details of the background of these personnel, with lists of publications, are available if required. A brief summary of the qualifications of key personnel is as follows:

T. I. McLaren - Experimental Physicist

Dr. McLaren has been involved with MARA Weather Dynamics Division since its inception in 1970. He has supervised many of the wind effects studies carried out by MARA and is current Manager of

the Weather Dynamics Division. Dr. McLaren's basic training was as a physicist, and after three years in the Fluid Mechanics Laboratory at M.I.T. he joined MARA in 1970. He is the author of numerous reports and published papers and has delivered a number of papers at international scientific conferences in Europe and the United States.

H. G. Norment - Theoretical Physicist and Meteorologist

Dr. Norment has many years of experience in air pollution modeling and mathematical simulations of meteorological fluid mechanics. He is the author of numerous reports and published papers. His previous fields of study have included work in the fluid mechanical aspects of airflow patterns shed from aircraft wing tips.

Consultants

Consultants to the Weather Dynamics Division of Mt. Auburn Research Associates, Inc. include:

J. A. Fay - Mechanical Engineer; Professor of Mechanical Engineering, M.I.T.

Professor Fay has an international reputation as a Fluid Dynamicist and has special interests in the dispersal dynamics of air pollutants in urban areas and from highway sources. He is a Fellow of the American Academy of Arts and Sciences, the American Physical Society, and is a member of the Atmospheric Environment Committee of A.I.A.A.

T. Fohl - Experimental and Theoretical Physicst

Dr. Fohl established the Weather Dynamics Division of MARA in 1970 and was closely involved with the Division's work prior to his move to Sylvania in 1972. He has maintained intimate contact with the work since that time in his capacity as consultant to Mt. Auburn Research Associates. Dr. Fohl has also worked extensively on vortex motions in the atmosphere.

J. Halitsky - Meteorologist and Engineer; Associate Professor of Civil Engineering, University of Massachusetts at Amherst

Professor Halitsky is internationally known for his work on the dispersal of plumes in the atmosphere. He has been especially active in studies of downwash effects which result from the interaction of an effluent with the aerodynamic wake of a nearby building or of the source structure itself.

Professor Halitsky has published extensively in the literature of plume dispersal dynamics and he is a member of the American Meteorology Society, the Air Pollution Control Association, and the American Association for the Advancement of Science.

A. A. Sonin - Aerophysicist; Associate Professor of Engineering, M.I.T.

Professor Sonin teaches graduate and undergraduate courses in basic and advanced fluid mechanics. His courses on applications in fluid mechanics have included architecturally induced wind problems, motivated by his insight into the nature of the problems. Professor Sonin is the author of many papers in various areas of fluid mechanics.

5. PERIOD OF PERFORMANCE AND PERSONNEL

The period of performance for the proposed study is estimated to be four/five weeks from date of commencement. A start date of 17 February is currently scheduled for the proposed sutdy.

Dr. T. I. McLaren will be Principal Investigator for the proposed study with other members of the MARA staff participating. Administrative responsibility will be carried by Dr. S. L. Kahalas, President of Mt. Auburn Research Associates, Inc.

6. COST OF STUDY

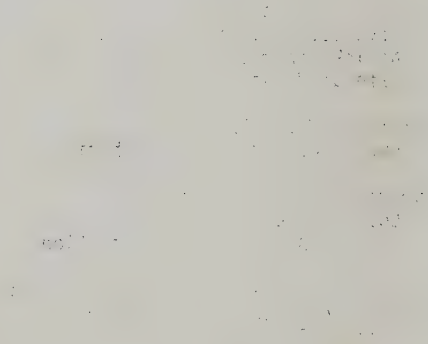
It is estimated that the proposed study will cost $12,190. Billings are made monthly for partial work completed, and are due within 30 days of presentation.

7. ADDITIONAL SERVICES AVAILABLE FROM WEATHER DYNAMICS DIVISION OF MT. AUBURN RESEARCH ASSOCIATES, INC.

Principal Consultant	$ 350 per diem
Senior Consultant	300 per diem
Wind Tunnel	150 per diem
Model Shop Facilities	150 per diem

8. LIABILITY STATEMENT

Mt. Auburn Research Associates, Inc. will carry out the work proposed here employing state-of-the art techniuqes. MARA personnel are familiar with on-going research in this field in the United States and a number of countries abroad. We believe that the results of the study will provide an accurate assessment of pedestrian level wind effects in the vicinity of the proposed Park Plaza development. However, we do not accept responsibility, financial or otherwise, for the consequences of this proposed study.



APPENDIX A

Mt. Auburn Research Associates, Inc. has performed theoretical and experimental tasks for:

U. S. Government Agencies

- Defense Advanced Research Project Agency (ARPA)
- Defense Nuclear Agency (DNA)
- Department of the Air Force
  - Cambridge Research Laboratories (AFCRL)
  - Weapons Laboratory (AFWL)
  - Wright-Patterson Air Force Base
- Department of the Army
  - Advanced Ballistic Missile Defense Agency (ABMDA)
  - Natick Laboratories
  - Safeguard System Command
- Department of the Interior
  - Bureau of Commercial Fisheries
- Department of Transportation
  - Coast Guard
  - Federal Aviation Administration (FAA)
- National Aeronautics and Space Administration (NASA)
  - Goddard Space Flight Center
  - Langley Research Center
- National Oceanic and Atmospheric Administration (NOAA)

Other Organizations (partial list)

- Avco Corporation
- Brown University
- Cabot, Cabot, and Forbes Company
- Commonwealth of Massachusetts
- Dow Chemical U.S.A.
- Hartford Fire Insurance Company
- Harvard University
- Massachusetts Institute of Technology
- MIT Lincoln Laboratory
- Pneumatic Scale Corporation
- Sasaki, Dawson, DeMay Associates
- State of New York
- City of Lansing, Michigan

APPENDIX B

WORK COMPLETED OR UNDER EVALUATION BY WEATHER DYNAMICS DIVISION

In addition to a number of U. S. Government contracts being carried out by Mt. Auburn Research Associates, Inc. in the field of upper atmospheric fluid mechanics, the Weather Dynamics Division has been active on the following projects:

1. Report on Expected Wind Effects at U/Mass Campus, Columbia Point, Boston, Massachusetts, submitted to McKee, Berger, Mansueto, Inc., Project Manager for U/Mass-Boston Project, September 1970.

2. Development of a Forecast of Wind Patterns Around Arctic Ice Pressure Ridges, submitted to U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, March 1971.

3. Wind and Pollution Control Study of the State University of New York at Buffalo/Amherst Campus, submitted to Sasaki, Dawson, DeMay Associates, Inc. and State University of New York, Albany New York, June 1971.

4. Wind Tunnel Studies of Wind Activity (i) at Base Level, and (ii) On Top Sports Deck of Proposed Symphony Towers, Back Bay, Boston, Massachusetts. Under evaluation by James Harris Associates, Boston.

5. Report of Preliminary Wind Effect Tests of Hartford Insurance Company Building, submitted to Sasaki, Dawson, DeMay Associates, Inc., April 1973.

6. Study of Pedestrian Level Wind Effects Near 60 State Street, Boston, Massachusetts, submitted to Cabot, Cabot & Forbes Company, June 1973.

7. Techniques for Wind Alleviation Near the Hartford Fire Insurance Company Building, Hartford, Connecticut, submitted to Sasaki, Dawson, DeMay Associates, Inc., June 1973.

8. A Study of Wind Alleviation Techniques at Some Buildings in Boston. Submitted to Cabot, Cabot & Forbes Company, August 1973.

9. A Wind Effects Study of the Hartford Plaza, Hartford, Connecticut, submitted to Hartford Fire Insurance Company, Hartford, Connecticut, October 1973.

10. Testing of Particulate Emission Levels on Boiler House at Logan Airport, East Boston, Massachusetts. Current contract with Joseph R. Loring Associates, Inc.

11. A Wind Tunnel Study of Plume Dispersal from Sources at the Dow Chemical Plant, Midland, Michigan. Submitted to Dow Chemical Company, August 1974.

12. A Study of Downwash Effects at the Ottawa Street Power Plant, City of Lansing, Michigan. Submitted to City of Lansing Redevelopment Authority, December 1974.

13. A Wind Tunnel Study of Air Flow Patterns Over Coal Piles at the AEP Plant, New Haven, West Virginia. Current contract with Smith-Singer Meteorologists, Inc.